A MILITARY APPROACH TO NETWORK-FOCUSED OPERATOR TRAINING FOR TRAFFIC MANAGEMENT CENTERS: A CASE STUDY FROM THE UTAH DEPARTMENT OF TRANSPORTATION'S TRAFFIC OPERATIONS CENTER

by

Benjamin Layman Shepherd

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SUPERVISORY COMMITTEE APPROVAL

of a thesis submitted by

Benjamin Layman Shepherd

This thesis has been read by each member of the following supervisory committee and by majority vote has been found to be satisfactory.

[redacted] Chair: Peter [redacted]

[redacted] Aleksandar Stevanovic

[redacted] Xuesong Zhou

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Peter T. Martin
Chair: Supervisory Committee

Approved for the Major Department

Chair/Dean

Approved for the Graduate Council

David S. Chapm[redacted]
Dean of The Graduate School

ABSTRACT

This thesis is a summary of work performed by the Utah Traffic Lab (UTL) to develop a training program for the Utah Department of Transportation (UDOT) Traffic Operations Center (TOC) operators. Operators who were normally trained on the job are now trained at the UTL prior to beginning work at the TOC. In order to conduct the training, the UTL began with the UDOT TOC mission statement and applied a military approach to develop individual training tasks required of operators. The UTL then organized these tasks into a concise, two-week training course that could be taught offsite at the UTL. The authors also updated the UTL video display and advanced traffic management system (ATMS) software package to mimic that of the TOC. This gave access to all ATMS devices in the Salt Lake City network and allowed the trainers to evaluate operators in a simulated work environment. Finally, the program was evaluated and adjusted after several iterations. Although training operators offsite is not a new technique, the UTL used the unique approach of focusing training on the regional transportation network and branching off into other relevant topics when appropriate. The UTL found that understanding the local and regional transportation network was the single most important factor in efficient incident management on the roadways. Likewise, incident management is the most important skill of the traffic operator. Other skills such as communicating efficiently with other agencies and operating ATMS devices are relevant and must be taught, but they are secondary to an understanding of the transportation network. This paper is a critical overview of the training methods developed.

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INTRODUCTION

The management of roadways in the United States has been important since the development of the interstate highway system in the 1940s. However, it is only in the past 20-30 years that dedicated traffic management centers (TMC) have been built with the purpose of monitoring freeways and implementing intelligent transportation systems (ITS) to help the freeways operate more efficiently. As these centers are built, staffing them with competent operators is essential. Since TMCs are often focused on the development and implementation of new technologies, the importance of training and evaluating new operators can sometimes be overlooked.

Literature Review

The Federal Highway Administration (FHWA) stresses the importance of traffic operator skills. According to their *Freeway Management Handbook* (1), "the degree to which a traffic control center meets the objectives of the freeway management system depends on how well the human operators are able to interface with the system devices." This handbook was one of the first manuals to formalize aspects of TMC development. Since its publication, both the FHWA and the Research and Innovative Technology Administration (RITA) of the US Department of Transportation have published several reports documenting the emergence of TMCs nationwide, as well as the training practices for operators.

The first national publication to specifically cover TMCs was the FHWA's *Comparable Systems Analysis: Design and Operation of Advanced Control Centers* (2). It summarized lessons learned from visits to 18 traffic management centers nationwide. One focus of the report was the human resource management of traffic management centers, particularly from a training standpoint. An entire section of the report covers staffing, selection, and training of operators. FHWA notes that, as was the case with UDOT, initial operator training is usually an "on-the-job" activity. FHWA also define the required operator skill set as "good verbal skills, a degree of computer literacy, and good reasoning skills according to the practices of several centers here and abroad." As vague as this description is, none of the literature reviewed provides a more detailed required skill set. It is interesting to note that even in an age of unprecedented technological developments, the focus must remain on these basic functions.

This role of the individual traffic operator was further discussed by FHWA (3), focusing on user-centered design. This concept is designing a system (in this case a TMC) around the individuals who will staff it, rather than designing around system software or other applications. Traditionally, TMCs have not utilized a user-centered design concept because they have been more focused on the ITS devices the operators control. This trend of neglecting the human side of the TMC appears to be a weak point in current TMC operator training research.

There are many tasks that operators must be trained to be considered competent. Although the qualifications for the traffic operator job are weakly defined, the list of tasks they must perform is exhaustive and has been thoroughly researched. *Design of an ITS-Level Advanced Traffic Management System: A Human Factors Perspective* (4) went into great detail in describing the operator job, specifically investigating the task list with which operators should be familiar. The report divided the job into six task types: communicating, coordinating, decision making, information processing, observation, and outcomes. For each of these task types, FHWA developed required and related tasks that an operator should be able to perform. In total, the report listed 363 required tasks and 463 related tasks. A more recent source of operator tasks is available through the Traffic Management Center Pooled-Fund Study (TMCPFS)(5). This report created a task list by beginning with 16 essential functions, dividing the functions into composite tasks, and then dividing the composite tasks into discrete tasks. To support the 16 functions, operators must execute 1,050 total discrete tasks (TMCPFS Appendix B)(5).

Recent research has focused on simulation evaluation of operators. Simulation exercises are essential in quantifying operators' abilities because they assess the operator under simulated real-world conditions. Gerfen (6) documents how the California Department of Transportation (Caltrans), the University of California-Irvine, and the California Polytechnic State University collaborated to create a training simulator for Caltrans traffic operator trainees using micro-simulation techniques.

Research Objective

After reviewing relevant literature, the UTL identified three research goals of the operator training program. They are:

1. Develop a list of critical operator tasks
2. Develop training techniques to teach tasks
3. Condense training into a two-week operator course

The development of critical operator tasks is essential because there is a discrepancy between job qualifications and expected abilities. Job qualifications, as defined by the FHWA, are simply to communicate well and understand relevant systems. However, having these qualifications does not necessarily ensure that the operator will be able to perform the many tasks expected of them as defined by FHWA and the TMCPFS. Therefore the initial effort of this work was to determine a finite list of operator tasks, relevant to the UDOT TOC that can realistically be taught in a two-week operator course. The second area to be improved is the method of training. From communication skills to camera operation to the posting of CMS messages, traffic operator skills are wide-ranging, and a "best method" of capturing these skills in a confined period of time is required. This paper presents a new approach to operator training, developed with a military approach and an emphasis on understanding the transportation network.

Overview of Historical UDOT TOC Operator Training

The Utah Department of Transportation's (UDOT) Traffic Operations Center (TOC) has not outsourced training of traffic operators, relying instead on training operators "on the job." This entailed shadowing a seasoned operator as they performed daily tasks. After an undetermined period of time, it was assumed that the new employee was proficient. Unfortunately, this method of on-the-job-training (OJT) resulted in inconsistent competence of newly hired operators. It also degraded the TOC's ability to manage the transportation network as seasoned operators had to be removed from the control room for training.

The essential problems with UDOT TOC operator training were that it was neither structured nor evaluated. A structured training program is important to ensure all topics are covered. Items taught during OJT are often seen once and then forgotten. Many items are not covered because they do not occur during the days on which the training occurs. For example, there are many seasonal tasks and responsibilities utilized by operators. A trainee who is hired in the summer may work for 6 months or more before managing traffic in a severe winter storm. When this storm occurs, the operator, now with 6 months of experience, should be a seasoned veteran. However, if it is his or her first experience with winter weather, the operator may be confused and be ineffective. Under the current model of OJT, there is no checklist of items for new hires to be trained.

The second problem with operator training is that it has not been quantified by evaluation prior to beginning work. There was a gradual level of increased responsibility as the new operator was allowed to operate independently, but there was no evaluation of abilities at the conclusion of training. Such evaluations are critical to provide a "check on learning" that ensures all topics have been trained to an expected standard.

For the first six months of this project, a graduate student worked as an intern at the UDOT TOC to gain the required familiarity with the job and processes. Throughout the six-month internship, the graduate student also had routine brainstorming sessions with the control room manager, who is responsible for employing all operators at the UDOT TOC. These sessions were important because the Control Room Manager was able to pass along his concerns with the current hiring, training process, and expectations for the research project. This six-month internship delivered a clear idea of the problem statement, the role of the traffic operator, and UDOT's desired end state for the project. The next step was to take the internship experience and format it into a two-week training plan for traffic operators.

INTEGRATING A MILITARY APPROACH TO TRAINING

Since the development of operator tasks are poorly defined in current transportation literature, the UTL researched other organizations that may have more of a focus on training in their day-to-day operations. The US Army is a highly-structured and well-trained organization. All procedures and events in the Army are directed, evaluated, and documented by an Army Regulation (AR) or Field Manual (FM). Also, because one of the most important tasks of the Army is to recruit and train new individuals to fill positions within the ranks, training of new employees has been refined to a very high level. This paper shows how a similar approach can be applied to operator training at Traffic Management Centers. The cornerstone of the Army's training program is FM 7-0 *Training the Force* (7). It defines how a given unit develops training tasks to meet organizational goals. It was decided to apply principles presented in FM 7-0 to the UDOT TOC, using the existing UDOT TOC mission statement to develop operator training tasks.

The Mission Essential Task List (METL)

An underlying premise of Army training is that every unit at every level has a mission statement. The mission statement captures what the unit must accomplish in order to be successful and is the starting point for all training. The difficult part is often determining from the unit's mission statement what training events should occur to keep the unit proficient. METL development is the vehicle that facilitates this training development. The METL is exactly what it sounds like – a list of tasks that are essential to the unit accomplishing its mission. Developing this METL is described in FM 7.0 as follows:

> *The METL development process reduces the number of tasks the organization must train and focuses the organization's training efforts on the most important collective training tasks required to accomplish the mission. (It) is the catalyst that keeps Army training focused on wartime operational missions (FM 7.0 Section 3.3-3.4, p. 3-2).*

This concept is well-suited to TMC operator training because State DOT's usually have a defined mission statement, but lack the structure or training program to support it. Although the DOTs do not have a "wartime operational mission" as described in FM 7-0, some of the 1,000+ operator tasks are more important than others. By using the METL development process outlined in FM 7-0, the authors were able to identify operator tasks that are necessary to allow the UDOT TOC to achieve its mission.

Developing the UDOT TOC Mission Essential Task List

The mission of the UDOT TOC is five-fold. It has been virtually unchanged since the inception of the TOC in 1995. It is as follows:

1. *We support UDOT and DPS activities to improve highway safety.*
2. *We operate the highway system to provide reliable and efficient travel time.*
3. *We provide accurate, timely, and useful real-time traffic information.*
4. *We work together with other government agencies to serve the public.*
5. *We provide excellent customer service.*

This mission statement is complete and directive in nature. This is important because it reinforces the most important aspects of the job on a daily basis. Missing is the derivation of training tasks from the mission statement. Implementing each of the statements above is only possible if individuals are proficient at tasks that enable the statement. Beginning with the mission statement, we developed key operator tasks for each tenant of the mission statement. They are listed in the Table 1 with the statement they support. This mission essential task list is more detailed than a generalized job description, but it is not overwhelmingly long. There are 22 tasks of various difficulties. While each task has to be taught using different techniques, simplifying the job into these tasks enabled building the two-week course from a list that is quantifiable but not unmanageable.

Table 1: Operator Mission-Essential Task List

1. We support UDOT and DPS activities to improve highway safety
Communicate effectively with the UDOT complex and DPS operators and dispatchers
Understand DPS computer automated dispatch (CAD); utilize to pull real-time incident data
Understand and have access to current highway safety statistics, trends, and publications
2. We operate the highway system to provide reliable and efficient travel times
Understand the regional and local freeway system, surface streets, and geography
Understand the interstate highway system (numbering, signing, impact on local area)
Recognize local traffic trends to enable more informed decision-making
3. We provide accurate, timely, and useful real-time traffic information
Operate the Commuterlink website
Operate closed-circuit television (CCTV) cameras to enable incident detection
Operate changeable message signs (CMS) to communicate real-time with travelers
Operate incident management system (IMS) to populate the Commuterlink website
Operate the 511 Traveler Information System Hotline
Operate highway advisory radio (HAR)
Monitor scanners and radio frequencies to enable incident detection
Operate remote weather information system (RWIS)
Operate the traveler advisory telephone system (TATS)
Send text updates (J-Page) on incidents to appropriate UDOT personnel
4. We work together with other government agencies to serve the public
Understand emergency procedures, such as AMBER alert, and respond appropriately
5. We provide excellent customer service
Maintain appropriate dress, appearance, and behavior at all times
Operate phone system with proper courtesies and competencies
Handle walk-in customers and group tours appropriately
Communicate with media members appropriately

DEVELOPING A NETWORK-CENTERED TRAINING COURSE

After developing critical operator tasks, the next goal was to developing a logical training program to teach all concepts in the most efficient manner possible. It was determined from observation and initial pilot training courses that the most critical component of an operator's knowledge is an understanding of the local transportation network, so the entire training course was built around this concept.

While the average traffic operator does not have to be a transportation engineer, they must have an understanding of the transportation network. The term "transportation network" defines the freeway and surface street network, as well as the travel trends, regional socio-economic factors, and geographic or topographic factors that can influence travel patterns. Every other component of operator competency is based on understanding the network. Unfortunately, novice traffic operators do not realize this when beginning work at the UDOT TOC.

Most casual observers would assume the job of the traffic operator is to scan CCTV cameras and post CMS messages. This is commonly accepted because these two devices are the most visible signs of a traffic management system. Although operation of these devices is part of the operator task list, there are many other responsibilities. Being able to operate these devices is useless if the operator does not understand the transportation network, because they will not be able to apply the capabilities of the devices efficiently if they do not know what they are looking at with the camera or who they are reaching with a CMS message. Since the job description is particularly vague, a new employee may often expect to learn how to operate cameras and signs and little else. This expectation leads to a poorly trained operator. It is imperative, therefore, to dispel this misleading expectation early in the course.

The Basics: Local Transportation Network and Regional Geography

There are several difficult aspects in teaching recruits an understanding of the transportation network. Unlike software that operates ATMS devices, there is no user manual for the transportation network. There is no checklist of items the trainee should understand. Further, some individuals are simply unable to think in terms of the larger transportation network. From a Transportation Engineer's standpoint, this is often difficult to imagine, because engineers are taught to consider the benefit of the system above the benefit to any one user. However, most commuters are not concerned with the efficient operation of the system, they are concerned with the ease of *their own* commute and the length of *their delay* at a given intersection. Operator trainees have to essentially be "broken" of this thought process, and taught to see the system in all its complexity.

This inherent self-centered nature of commuters became clearly evident after several training sessions with new operators. Operators were usually very familiar with the routes they normally drive, and many had even noticed the locations of ATMS devices near their homes or workplaces. However, they often failed to realize how their local area fits into the larger regional network. This discovery led to teaching the transportation network by starting with a larger overview and working to a smaller, localized understanding. This "larger to smaller" approach was applied to each major area taught – roadway design and characteristics, regional geography, and travel trends.

Roadway Design and Characteristics

To start with the large picture of the road network, the initial class is on the Interstate highway system, beginning with the map shown in Figure 1, the interstate highway configuration. Many people have driven on Interstate highways for years, but do not understand how the numbering system is organized, how mile posts are counted, or how bypass routes are designated. For many people, "interstate," "freeway," and "highway" are all synonymous. We

Figure 1: Interstate Highway Configuration

teach how the local portion of the interstate system is part of a much larger system that has national implications for both freight movement and passenger travel. Most individuals who travel on a particular freeway segment every day recognize it as the "road they take to work." Few also realize the vital role it may play in moving the nation's freight, or in connecting the East and West coasts. For example, in Utah, operators have to understand that if I-80 is closed through Parley's Canyon (the local pass through the Wasatch Mountains) it not only affects tourists visiting Park City, Utah, but also affects the nation's economy. Once an understanding of the nation's highway system is achieved, operators are trained on the local streets, beginning with non interstate freeways and continuing to important US and State highways, followed by principle arterials in the urbanized areas. They are taught to recognize key parts of the highway infrastructure, particularly dangerous intersections, and basic principles of traffic flow and signal timing. Again, they do not need to be traffic engineers, but they should be able to communicate with professionals in engineering language. Appendix H contains images used during training to illustrate different types of roads and roadside infrastructure, as well as their characteristics and capabilities.

A unique method to help trainees learn the transportation network was developed. On the first day of training, after a brief introduction, the trainee was instructed to sketch a map of the local system of roads. Trainers deliberately gave limited guidance to encourage the trainee to think for themselves. After drawing the first map, which usually included little more than a freeway and local roads near the trainee's home, the instructor drew a "better" map of the local network as an example. The instructor's map was drawn as shown in Figure 2. A specific technique for drawing the map was used to help the trainee learn it more quickly. Similar to the class structure, the trainees were told to start with the big picture and work to the small – beginning with interstate highways, interstate bypasses, local freeways, and then principle arterials.

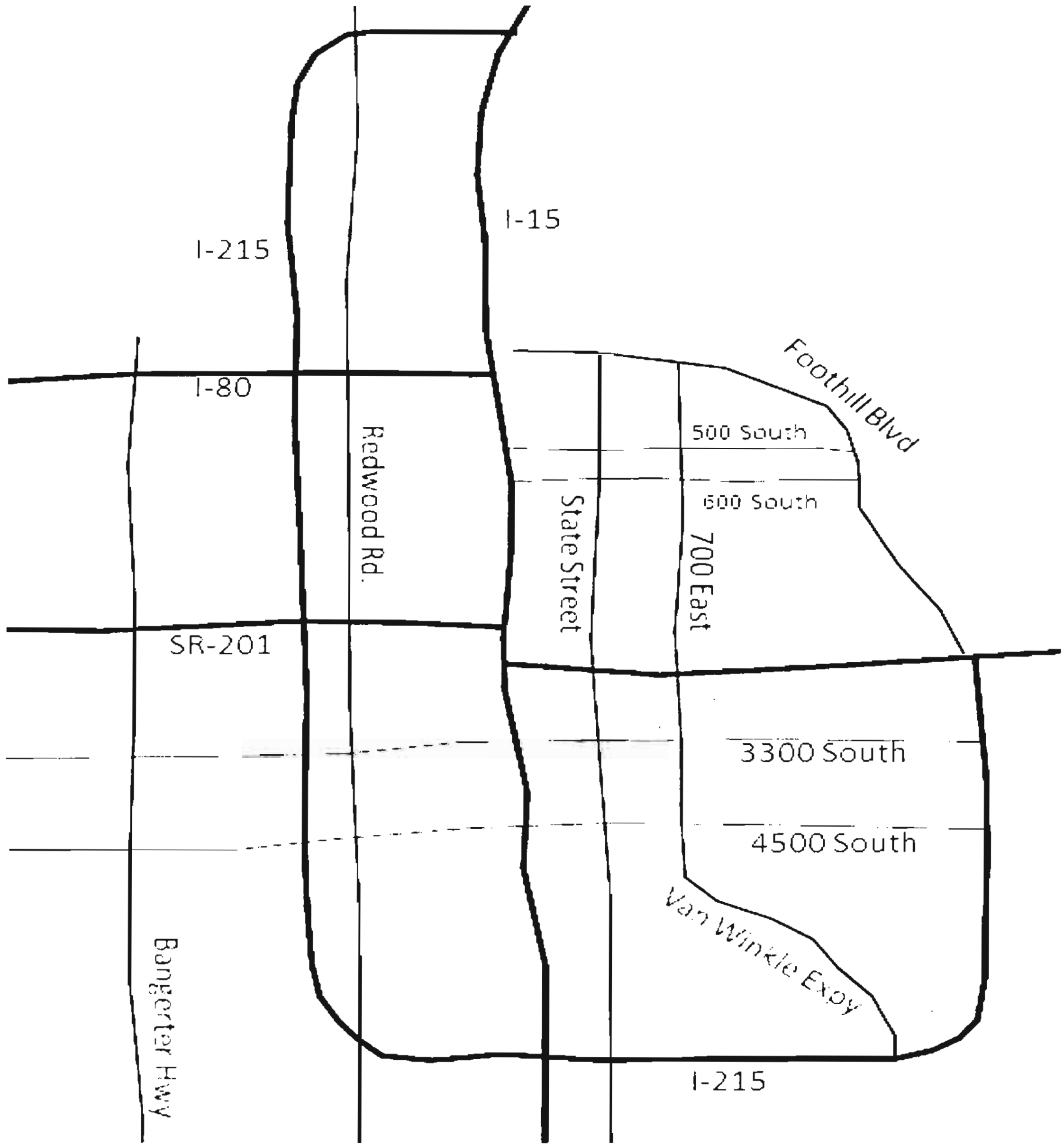


Figure 2: Local Map Sketch

Drawing the local map was repeated several times daily at the outset of training sessions. After a few days, the operators were fairly comfortable with the local network. The instructors then introduced regional and state-wide maps, drawn the same way. The maps were to be drawn with as much detail as possible, as was appropriate to the scale of the map. On the state map, the trainee was required to include all freeways, as well as alternate routes between major cities or through areas that may be impassible in winter conditions. On the regional map, the trainee was required to include regional cities, with all freeways and principle arterials that service each of the cities. Locally, the trainee should include great detail in the metropolitan area, to include all arterial streets and mileposts along freeways. With constructive criticism throughout the week, each sketch became more and more complete until ultimately, the operator could draw each map as well as the instructor.

The reason for delivering map sketches is that if trainees can draw a map of the area from memory, they will also be able to consult that map in their head when they hear an incident location called out by a dispatcher. They should be able to place the incident on the map in their heads and immediately recognize what may be happening around the incident and what else it may affect. This proved to be the most effective technique of the entire course. Once the trainee had the map of the region visualized, it was easy to overlay cameras, signs, and other ATMS field devices onto the "mind map." The local and regional maps are drawn sequentially in Appendices B and C, respectively.

Techniques for Incident Management

The primary mission of the traffic operator is to contribute to efficient incident management. If a State TMC had a "wartime operational mission," as described in FM 7-0, it would be incident management. The most important operator task, and the most difficult for the vast majority of operators, is locating and verifying incidents. Traffic management centers are often the "eye in the sky" for incident management. Although operators are not first responders, closed-circuit television (CCTV) camera access allows them to help the emergency service personnel. They can identify critical details about the incident and relay this information to the first responders. With a photographic "mind map," operators can quickly identify an incident's location and impact on traffic. Once they have digested this information, which takes a seasoned operator only a few seconds, they can begin the process of finding the incident on camera to verify critical information. This requires two skills that are often very difficult for operators to master – selecting the correct camera and locating the incident on that camera. Both of these skills rely on a traffic operator's detailed understanding of the geography of the area.

With a good "mind map," the ease of selecting the correct camera is largely dependent on the software application that controls the cameras. Cameras that are named and listed logically will be helpful to the operator. Mileposts are the most common method of labeling cameras because traffic management systems are most concerned with freeways. However, mileposts are often unfamiliar to operator trainees who have grown up locally and understand the local grid system of roads. Further complicating matters for operators is the fact that many arterials use a common name different than their grid number. For example, State Street in Salt Lake City, which is probably the largest arterial in Salt Lake County, is 100 East on the grid. Operators have to be aware of this, because if they are looking for an incident located at 200 East, they should consider a State Street camera. If they are unaware that State Street is 100 East, they will waste valuable seconds searching for a camera on 200 East that may not exist. Another principle arterial in Salt Lake County is Bangerter Highway. Bangerter Highway is one of the few roads in the valley that runs both South-North and West-East. In the Northwest part of the county, Bangerter Highway is approximately 4000 West on the grid. It travels south out of the populated area and turns East at approximately 14000 South. Many operators who live in the Southern portion of the county think Bangerter Highway is just a West-East running road at 14000 South, while many people from Salt Lake City think it is just a South-North running road at 4000 West.

When traffic operators hear an incident on Bangerter Highway, they have to be able to use the mile post or cross street provided to determine what effect the incident may have on the network and select an appropriate camera.

Local geography becomes even more important to the traffic operator once they have selected the appropriate camera. While many TMCs enjoy excellent coverage of freeway system with CCTV cameras, camera spacing varies. The operator will usually have to maneuver the selected camera, and often numerous cameras must be selected. This requires that operators determine where the camera is located, where the incident is located in relation to the camera, and the direction in which the camera is looking. Adding to the difficulty is that many initial reports are unrefined and do not give an accurate incident location. For example, when a citizen calls 911 to report a crash on the freeway, the DPS dispatcher will initially ask for their current location. Travelers will often look to the next guide sign to make this determination. This is the location the dispatcher will enter into the CAD for the incident location. However, the citizen can sometimes be a mile or more down the road before he or she gets through to a dispatcher and gives the report. In this case, the location given is not an accurate location for the incident itself.

All this confusion of location is addressed by the skill of the operator. By knowing which direction the traffic is headed, as well as the geographic and network conditions, an experienced operator can anticipate some of these problems, which will enable them to select the correct camera quickly. Although this is a skill that often takes operators months to master, teaching some universal methods for recognizing location and direction were very helpful in developing this skill quickly in new operators. One of the best ways to orient a perspective is by using topographical features, which are more readily available in the Salt Lake Valley than they may be in other areas. The metropolitan area is bordered by the Wasatch Mountains in the East and the Great Salt Lake in the West. If an operator selects a camera but does not initially recognize the image, he or she can scan up to the horizon to see if they see mountains, or if mountains are on the left or right of the image they are seeing. If the mountains are in the background of an image, the operator is facing East. In this region, this is the most universal method of recognizing direction. In Figure 3, a camera at I-15 and Beck Street in North Salt Lake shows morning traffic with the Wasatch Mountains on the left. Using the topographical features, the operator can immediately tell that the approaching vehicles are Northbound, since the mountains are in the East. Buildings or local landmarks can be used similarly to orient a view, although they will not be as universally applicable as the mountains. Along portions of the I-215 West loop in Salt Lake City, the freeway serves as a dividing line between residential and industrial areas. If an operator selects a view of I-215 West at 700 North, he or she can immediately determine that the houses are on the right of the freeway and the warehouses and trucks are on the left. With an understanding of the local geography and economic demographics, the operator will quickly identify that the camera is facing North.

Another method is using shadows. Most people understand that the sun rises in the east and sets in the west, but not nearly as many think to use this information to understand a given video image. This is particularly helpful during the busiest times of the day, the morning and evening commutes, when shadows will fall in opposite directions. Also helpful is the fact that operators always work the same shift (either morning or evening), so the shadows are always consistent when they are working. For example, in Figure 4, the shadows of the vehicles are falling to their left, and the time stamp on the image is 5:14 PM. In this case, the sun is setting in the West, the shadows are falling to the East, and the traffic is Southbound. The operator can then decide, based on the incident location, if he or she needs to pan the image to the opposite direction or select another camera to verify the incident.

Figure 3: I-15 at Beck Street (North Salt Lake) Camera Image

Figure 4: I-15 at 8600 South Camera Image

A third method of orienting to a given camera view is by observing the traffic on the road. This is helpful on many routes in Salt Lake County because commuter traffic is heavy along I-15 and truck traffic is heavy along I-80. Most operators are less familiar with the camera images in Davis and Utah counties, immediately north and south of Salt Lake County, and sometimes have difficulties identifying the image they are seeing. During the normal commuter periods on I-15, operators can zoom out as far as possible and observe the overall volume in each direction. In Figure 5 there is an obvious difference in the volume of traffic approaching the camera and the volume of traffic driving away from the camera. The time stamp in this image is 5:14 PM. Since this area is north of the downtown area, the heavier traffic is traveling North, leaving town.

There are two useful techniques that can be used with cameras along I-80 East of Salt Lake City. Through Parley's Canyon, I-80 climbs from 4500 to 7000 feet in about 15 miles; many stretches have 7 or 8% grades. This region is mountainous and less traveled than I-15; as a result shadows and commuter traffic trends are often not helpful. However, operators can still observe the traffic and use the speed of truck traffic to determine direction. In one direction the trucks will usually travel at 25-35 miles per hour with other cars passing in the left lane, while in the other direction both trucks and passenger vehicles will be traveling at comparable speeds. The slow trucks are always heading east up the mountain. Another way to determine direction is by understanding which side of the road the camera is on. For these cameras in Parley's Canyon, operators always have an additional note letting them know the side of the freeway (north or south) on which the cameras is located. The image in Figure 6 is coming from a camera on the South side of the road. By knowing this information, the operator can deduce that the road is to their north, the traffic coming toward them is Eastbound, and the traffic going away from them is westbound.

Figure 5: I-215 West at 700 North Camera Image

Figure 6: I-80 Camera Image in Parley's Canyon

Travel Trends

Traffic operators must be taught a basic understanding of local travel trends. This can be helpful for identifying location and image, but it is equally important to understand the impact of an incident on the network. Operators should understand why a similar crash in the same location will have different impacts at 7:00 am than it will at 5:30 pm. They also have to understand where important facilities and businesses are located, as well as special events hosting sites. In Salt Lake City, the airport, the headquarters of the Church of Jesus Christ of Latter Day Saints, the Utah state capitol, and the University of Utah are all population and economic centers in the city. As a result of Utah being very rich in natural resources, there are three oil refineries, numerous rock quarries, and the Bingham Canyon Mine, the largest open-pit mine in the world. There are also many regional distribution centers in the western portion of the valley that lead to Salt Lake City being called the "crossroads of the West." Traffic operators have to know the locations and general operations of these facilities to determine what type of traffic is projected onto the network. Although they do not need to capture the detail that an urban planner would, the operators should understand how the socio-economic characteristics of the region affect the local traffic.

Software Programs, Policies, and Procedures

After an in-depth understanding of the network is achieved, the trainee still needs to learn various day-to-day operations and programs used by operators. The UDOT TOC uses the TransSuite software package to operate all ATMS devices and conduct incident management. These programs, as well as UDOT internal policies and procedures, comprise the remainder of the operator course. The benefit of teaching the road network and regional geography first is that it is much easier to learn the location and capabilities of ATMS field devices with a thorough understanding of the network.

The TransSuite package consists of four applications commonly used by operators: the ATMS map, incident management system (IMS), traveler information system (TIS), and the video control system (VCS). When learning these programs, the operators used them as they would in the course of managing an incident. The standard operator procedure for incident management is:

1. Verify incident on camera
2. Post CMS sign if applicable
3. Create incident in IMS (populates Commuterlink website and 511)
4. Monitor until incident is cleared

In order to stay with this operational flow, the programs were taught in the order they would be accessed, beginning with incident detection, followed by VCS, TIS, and IMS. Screenshots of each of these software packages are included in Appendix G. Initial training sessions revealed that none of the software programs were difficult to master for the newly-hired operator. All are Windows-based and operate with familiar toolbars and functions.

Understanding the initial incident report given over the radio can be difficult for a new operator. Since the UDOT TOC is directly linked to the highway patrol dispatch center, all traffic over the radio is in "police speak," using the state 10-codes and other acronyms. While all incidents called out over the radio will eventually be posted to a computer automated dispatch, it is very important for the operator to capture all relevant information from the first radio call-out. The seconds (sometimes minutes) between the radio call-out and the posting of the incident on CAD are critical -- if the operator can verify the incident in this interval, they may save hours of residual delay from the crash later. Unfortunately, it usually takes new operators a few weeks to become proficient at picking up the radio traffic. The relevant state 10-codes and commonly-used acronyms were taught in the classroom, allowing the operators to identify incident locations more quickly upon beginning work.

The one operation of incident management that relies heavily upon current research and accepted practice is CMS messaging. Although TIS is the program the UDOT TOC utilizes to post messages to signs, more classroom time is spent on messaging theory and application than on the TIS program itself. Operators must understand the importance of CMS messages since they reach the most critical travelers – those immediately approaching the incident. While IMS is important because it populates the Commuterlink website, the 511 travel advisory hotline, and other public outputs, none of these outlets have as much of an immediate effect on the network as a CMS message. Operators also must understand the basic human factors involved in CMS messaging, such as: sign readability based on letter height and approach speed, use of easily recognizable phrases, and message phasing. Although the TIS program and many signs are highly advanced, the best practice is to keep messages as clear and concise as possible.

CONCLUSION

The operator training course has evolved with each iteration. The drawing of local, regional, and state maps was not introduced until the third iteration, while some software programs were introduced in the classroom initially, but later moved to the simulation portion of training. Overall, the course has been successful and has met all research goals. Prior to this project, the expected timeline for an operator to be "proficient" was two to four months after hiring. It was not until this point that the control room manager was able to confidently leave the operator alone in the TOC for a shift. For individuals who have been trained at the UTL, that time has been reduced to 10-14 days, and eliminated the requirement for a supervisor to be involved in training. This shorter training time gives the control room manager much more flexibility when making personnel decisions. For example, if an operator has been working at the TOC for 3 months but has had trouble making progress, the control room manager had a difficult decision – retain the individual in hopes that their performance would improve, or let them go and risk spending another three months in training. By outsourcing the training to the UTL, the control room manager knows that he or she can make a personnel move and have a well-trained operator replacement in 2 weeks or less.

Another benefit to the operator training course is the flexibility to customize the training to meet the needs of the individual being trained. To date, five UDOT TOC operators have been trained at the UTL. These individuals had quite different backgrounds and levels of experience upon entering the training course. One was an 18-year-old high school graduate who has lived in the Salt Lake Valley his entire life. Another operator was a 32-year-old who had recently moved to the area from another large metropolitan area. A third was an operator who had been working at the TOC for nearly 5 months, but was having trouble progressing. This diverse background was very helpful, as each trainee required different training goals and classes. The low volume of trainees makes it possible to customize the training program to the individual, a luxury many larger metropolitan areas may not have. For example, the youngest trainee was very familiar with the local area, but had only been driving for two years and therefore did not have a wealth of knowledge of transportation in general. The 32-year-old began the course with virtually no knowledge of the local transportation network, although she possessed many useful professional and interpersonal skills. These two individuals required very different training programs to reach the same level of proficiency in all tasks. In a large operations center, the training program most likely would not have the flexibility that the UTL's training program offers UDOT.

DISCUSSION

The operator course has been effective to date, but a number of limitations still need to be addressed. One of the largest obstacles is the private nature of much of the information gathered, analyzed, and disseminated at the TOC. The UTL will most likely never have access to the CAD or radio traffic coming from the DPS dispatch center. Since the TOC is co-located with dispatch, operators have easy access to these outlets without compromising the private nature of the information. The UTL, however, is located 5 miles from the TOC, and is a less secure facility than the TOC building. So DPS is reluctant to provide access to the CAD and radio frequencies at the UTL. This is unfortunate because listening to the constant radio transmissions and extracting relevant information is one of the most difficult and important skills of the operator.

Another limitation to the training program is the overall layout of the UTL. The TOC layout features a central control room with administrative offices adjacent, whereas the UTL has more of an open floor plan. The video wall is in the same room where all graduate students work throughout the year. This setup does not allow operator trainees to focus on the operator job as they would in the control room. When an operator enters the control room for the first time, they recognize immediately that they are in a secure, important information hub. Thus, they immediately respect the important nature of their job. The traffic lab, because it serves many purposes, cannot convey the same feeling to the operator. It has the feel of a library or open study room. This limits the instructor so as not to disturb other students, and it limits the operator because they often cannot take simulations as seriously as they would in the control room. The traffic lab is moving to a new location in the next year. A recommendation is to recreate this "operations center" feel in a portion of the new lab, where simulations can be conducted.

A final limitation is that the UTL cannot train and evaluate an individual's character. A common description of work in an operations center is "hours of tedium interspersed with moments of terror" (8). While traffic operators deal with periods of high stress and multi-tasking, they also deal with periods of very limited activity throughout the less-busy times of day. Operators are required, even during slow periods, to monitor cameras and maintain situational awareness of the network. Ultimately, a large number of individuals will not be able to maintain focus during some of these slower periods, which will degrade their ability to manage an incident when it happens abruptly. In the current operator training program, there is no way for the trainer to evaluate how the individual will perform in a similar situation. Because of the emphasis on a condensed course, the focus has to be on maximizing training, not on training to be bored. There are a number of ways to approach this problem. One recommendation is that UDOT investigate the possibility of administering a personality test during the hiring process. This type of test may indicate elements of the individual's character that are not suitable for work in an operations center. Another recommendation is to give the trainee the opportunity to display character traits by assigning routine tasks and observing his performance. For example, if an operator is given a seemingly meaningless task, his or her only motivation to perform the task to a given standard is that the supervisor requires it. This can often be a good indicator of character. Those trainees who are willing to dedicate time and energy into completing the task are also likely to be reliable when left alone in the control room. Regardless of the approach, it is recommended that additional research is done to determine methods of evaluating individual responsibility and character before hiring.

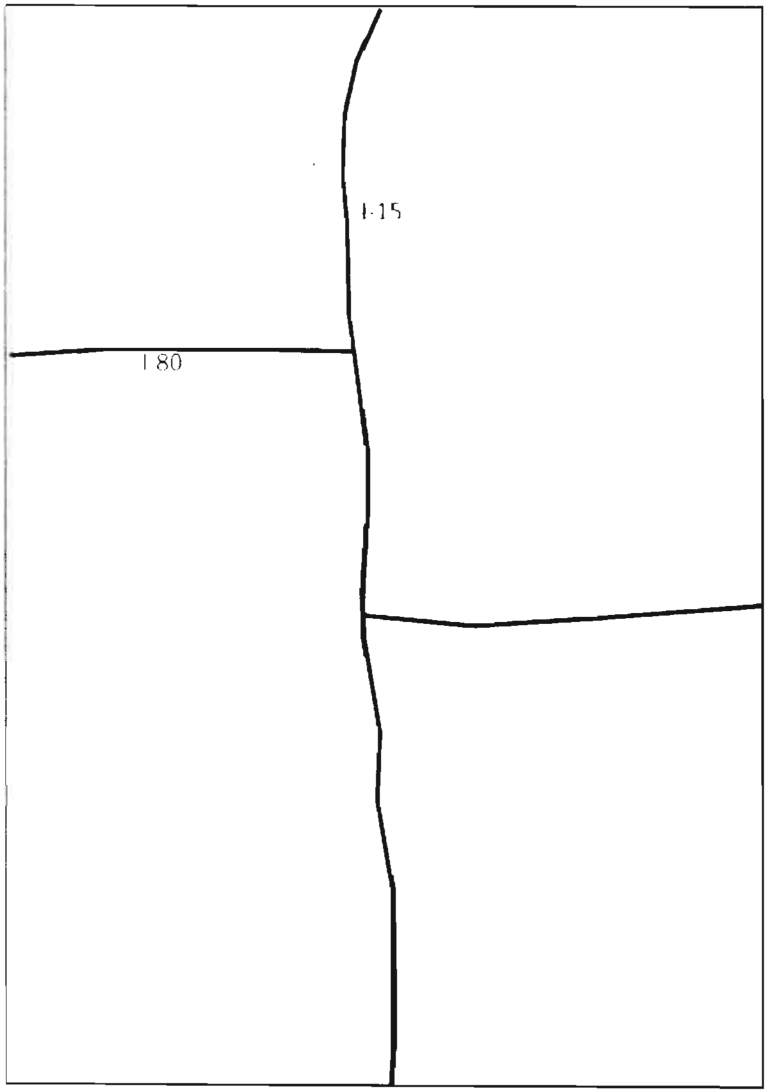
APPENDIX A

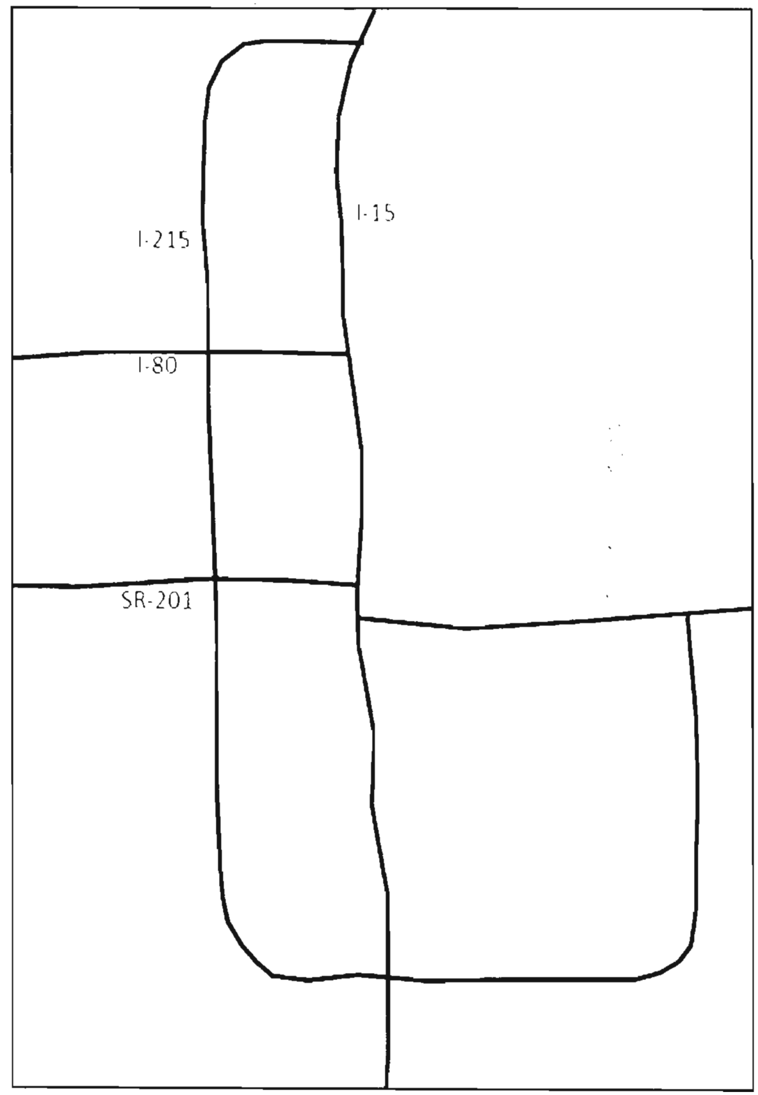
LIST OF ACRONYMS

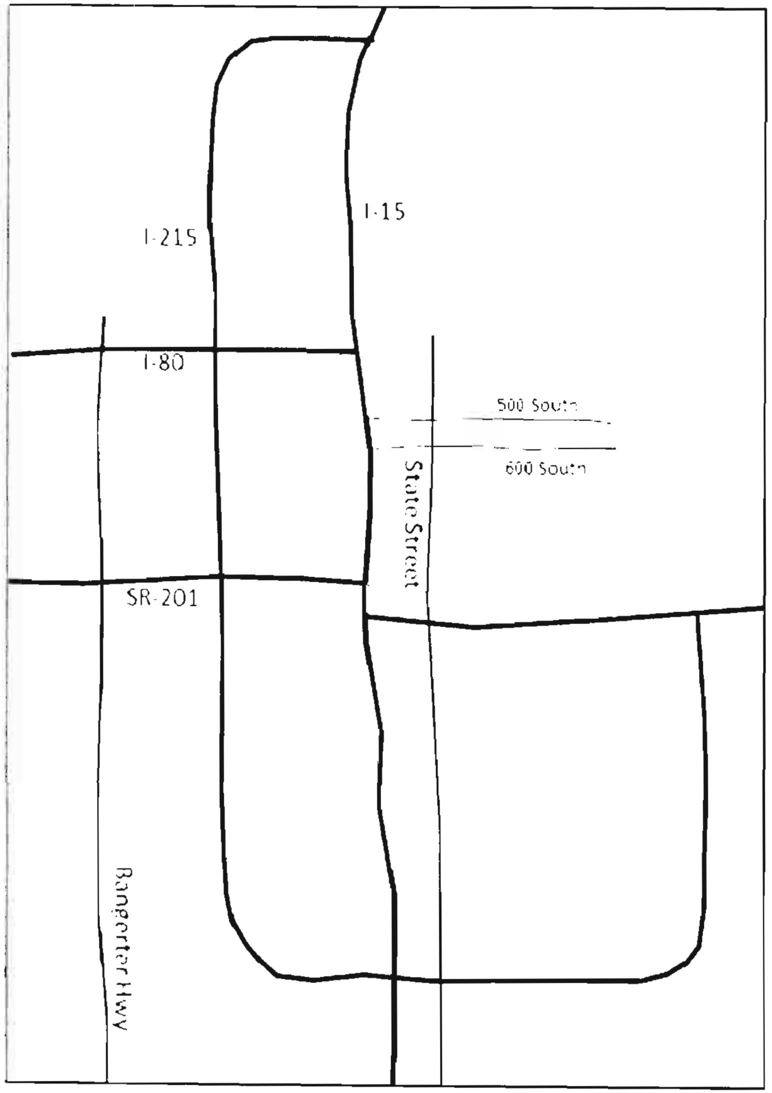
AR	Army Regulation
ATMS	Advanced Traffic Management System
CAD	Computer Automated Dispatch
CCTV	Closed-Circuit Television
CMS	Changeable Message Sign
DPS	Department of Public Safety
FHWA	Federal Highway Administration
FM	Field Manual
HAR	Highway Advisory Radio
IMS	Incident Management System
IMT	Incident Management Team
ITS	Intelligent Transportation Systems
METL	Mission Essential Task List
RITA	Research and Innovative Technology Administration
RWIS	Remote Weather Information System
TATS	Traveler Advisory Telephone System
TIS	Traveler Information System
TMC	Traffic Management Center
TMCPFS	Traffic Management Center Pool Funded Study
TOC	Traffic Operations Center
UDOT	Utah Department of Transportation
UHP	Utah Highway Patrol
UTL	Utah Traffic Laboratory
VCS	Video Control System
VMS	Variable Message Sign

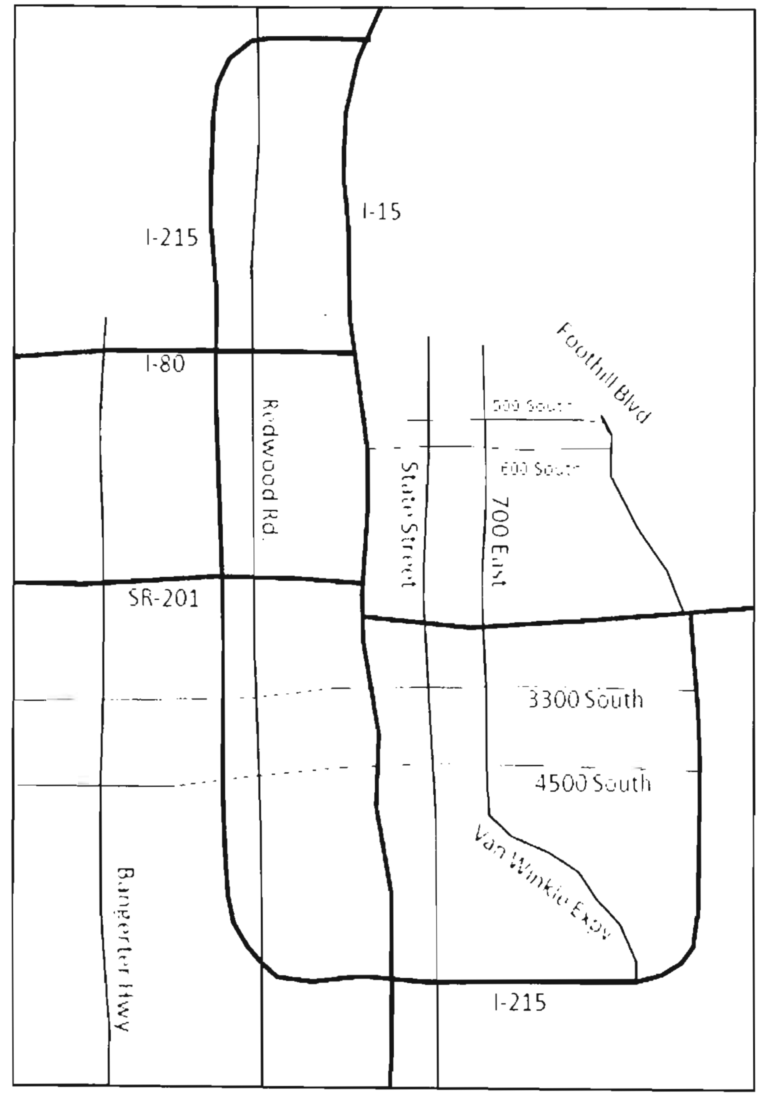
APPENDIX B

DRAWING LOCAL MAP


I-15
I-80

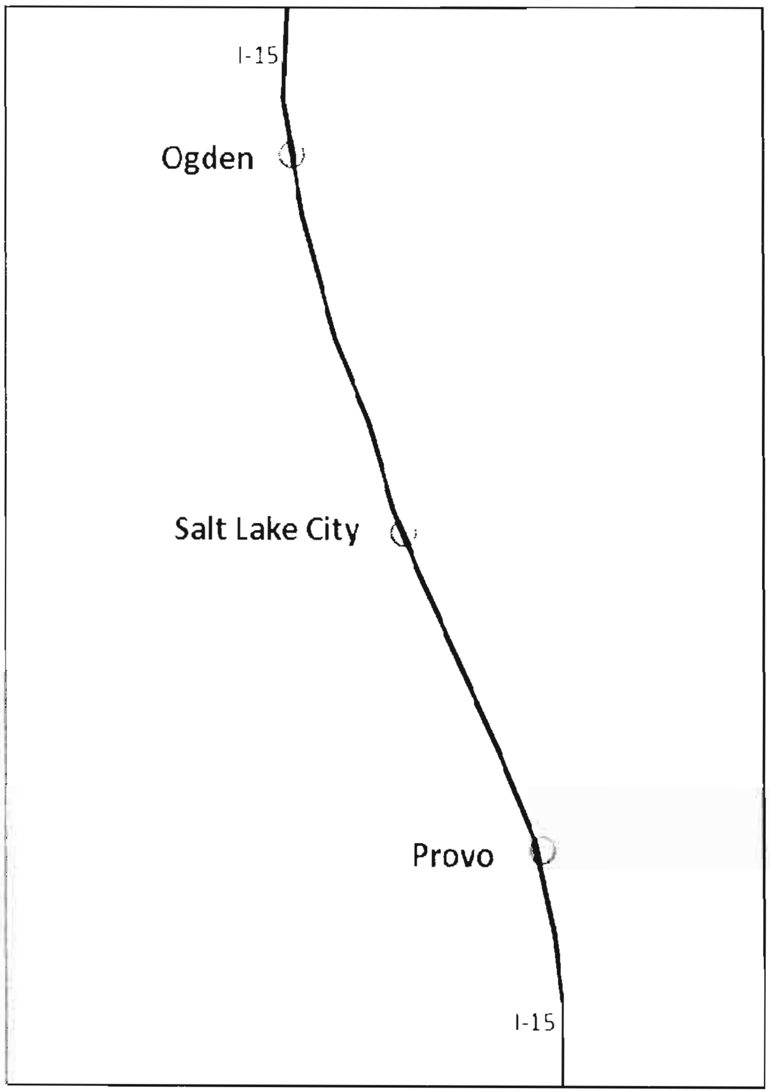

I-215
I-15
I-80
SR-201

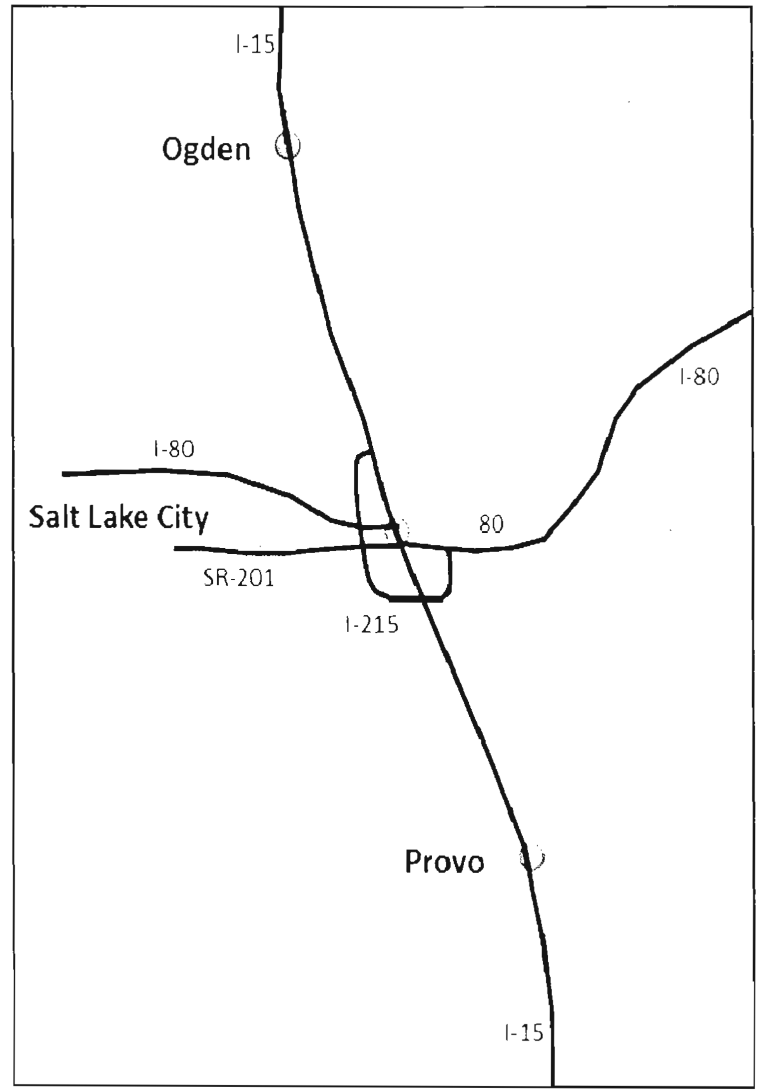

I-215
I-15
I-80
500 South
600 South
State Street
SR-201
Bangerter Hwy

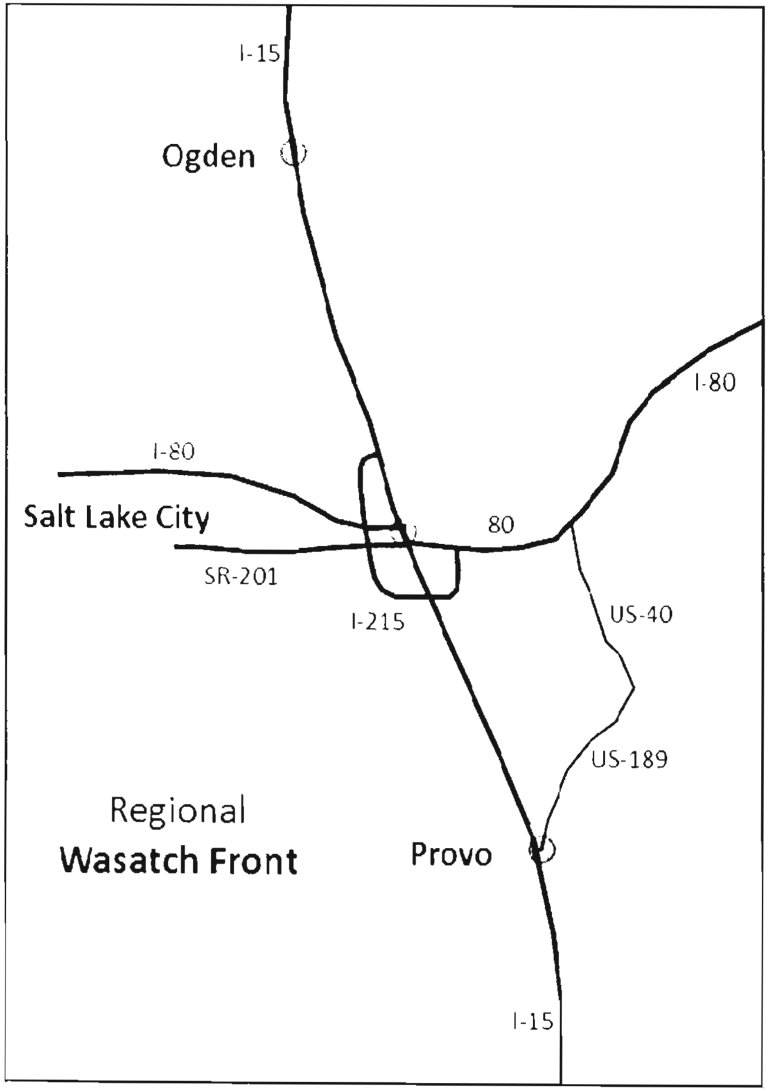

I-215
I-15
Foothill Blvd
I-80
500 South
600 South
Redwood Rd.
State Street
700 East
SR-201
3300 South
4500 South
Van Winkle Expy
Bangerter Hwy
I-215

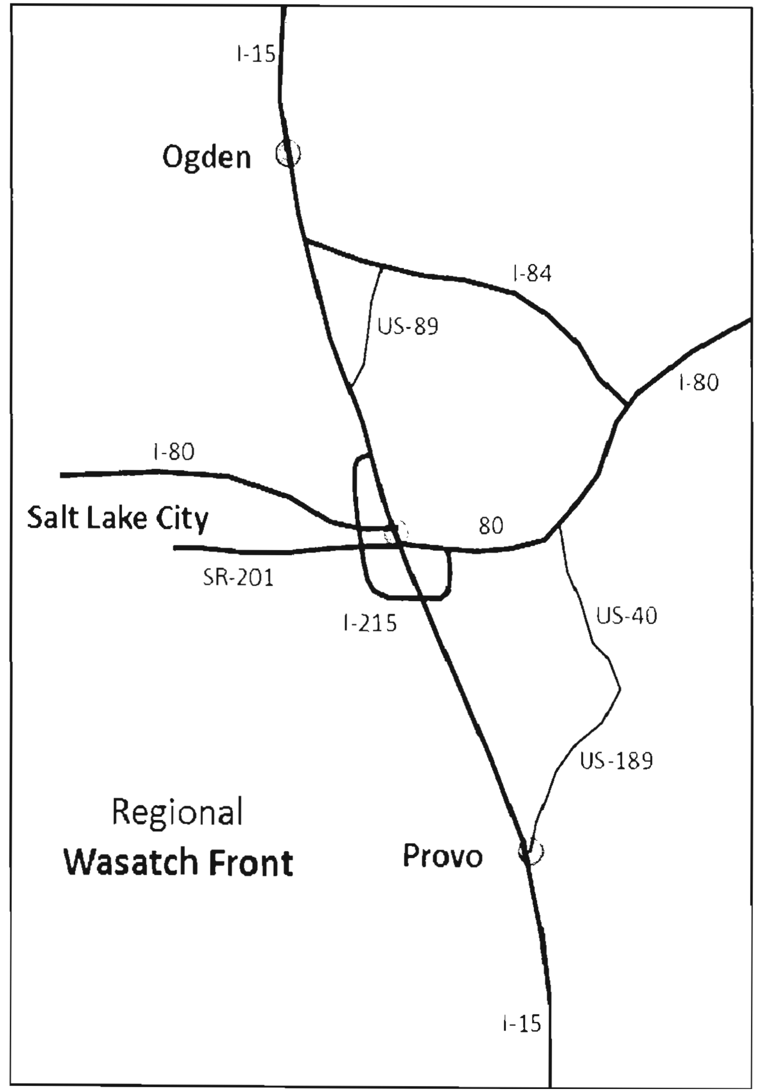
APPENDIX C

DRAWING REGIONAL MAP


I-15
Ogden
Salt Lake City
Provo
I-15


I-15
Ogden
I-80
I-80
Salt Lake City
80
SR-201
I-215
Provo
I-15


I-15
Ogden
I-80
I-80
Salt Lake City
80
SR-201
I-215
US-40
US-189
Regional
Wasatch Front
Provo
I-15


I-15
Ogden
I-84
US-89
I-80
I-80
Salt Lake City
80
SR-201
I-215
US-40
US-189
Regional
Wasatch Front
Provo
I-15

APPENDIX D

OPERATOR INITIAL EXAM

Name:

1. Why are CMS messages important?

2. What is the part of the signal that has the green, yellow, and red bulbs?

3. Name a city in each of the UDOT regions.

4. How many degrees from its original position must a signal head be twisted to warrant an emergency work order?

5. List all the freeways in Utah.

6. Name three facilities in the SLC area that host special events.

7. Name an interstate highway that could be in North Carolina and New York.

8. What is the local name for the junction of I-80 and SR-201 West of Salt Lake City?

9. What three elements always go on a CMS message?

10. What is the name of the grassy area between the curb and the sidewalk?

11. What is the highest possible Level of Service you can achieve? What is the lowest?

12. Define the levels of severity of crashes.

13. What is the phone number to the TOC?

14. At 6:45 AM, similar incidents occur at the following two locations. Which will have a greater impact on the transportation network?

I-15 South @ 500 South in Bountiful
I-15 South @ 12300 South in Draper

15. How many mileposts are there on I-215?

16. There is a quarry located on I-80 East of Salt Lake City. On which side of the road is it located?

17. What facility is located at the Northern end of Bangerter Highway?

18. How many words are allowed on a CMS in a 65 mph zone? A 40 mph zone?

19. What is the name of the (normally black) piece that surrounds a signal head?

20. On the CAD screen, what does a "T" before a unit's identification number represent?

21. When viewing an image on a CCTV camera, what are two methods you can use to determine the direction the camera is facing?

22. How many mileposts are there on I-15 (approximately)?

23. What are the names of the two TRAX lines in Salt Lake City?

24. What surface street connects I-215 East with the University of Utah?

25. What counties border Salt Lake County in each cardinal direction?

26. How many lines of a CMS message can you phase? How many phases can you use?

27. In a traffic signal structure, what is the horizontal pole called?

28. Name three types of roadside barriers.

29. What county's incidents do not appear on the CAD?

30. List the steps an operator should take (in order) once notified of an incident.

31. What is the local name for the junction of I-80 and US-40 Northeast of Park City?

32. Where does I-80 begin and end (nationally)?

33. The city of Ogden is located at approximately what milepost on I-15?

34. Due to the way it was constructed, incidents are often more difficult to locate on I-215 South than on other freeways. How is it different?

35. Name two types of concrete barriers. What are the practical differences?

36. What is the 10-code for a traffic accident or crash? What different types are there?

37. Name two current UDOT freeway construction projects.

38. What is the local name for the convergence of I-15, I-80 East, and SR-201?

39. I-80 East Eastbound is blocked through Parley's Canyon. A caller from Provo requests another route to Park City. What would you tell them?

40. What is unique about the intersection of Bangerter Highway and 3500 South?

41. What are three methods of identifying location on a CMS message?

42. Name four types of road signs.

43. According to the current version of the MUTCD, a one inch letter is readable at what distance?

44. What incident severity levels require an operator to send out a J-Page message?

45. What is the complex?

46. What is the local name for the Salt Lake and Utah County line on I-15?

47. What are control cities? From Salt Lake City, what are the control cities in each cardinal direction?

48. Operators place work orders for traffic signals that are owned and maintained by UDOT. What other agencies own and maintain signals in the Salt Lake City area?

49. How long are skipped lines? How long are the gaps between them?

50. In the space below, list every acronym you can think of associated with the Traffic Operations Center. Next to each, write what they stand for. On the next three pages, draw maps of the local, regional, and state transportation networks.

APPENDIX E

CLASSROOM SCRIPT

Introductions

- Expectations
- Paper and pen
- Classroom portion
- Acronyms
- Research partnership
- "I write-you write"
- Console portion

"**Operator Introduction**" slideshow

Testable Material:

- UDOT Regions
- TOC Functions
- Most important task of operator: incident management
- Primary outputs
- Control room layout
- Acronyms: UDOT, TOC, TMC, ATMS, CCTV, 511, HAR, VCS, IMS, CMS/VMS, TIS
- Commuterlink website

Draw local map (guidance = freeways and big surface streets)
Instructor draw local map
"Drawing Local Map" slideshow

Break

Draw local map
Critique map

"**Road and Traffic Basics**" presentation

Testable Material:

- Road types (in TOC)
- Difference in freeway and surface street
    - Express lane basics
- Lane numbering
- Flow, speed, density
- Typical cross section
    - Gore, soundwall
- Typical signal structure
- Measuring distance
- Barrier types
- Sign types/examples

Questions/Review: Road and Traffic Basics

Draw regional map (guidance = include Ogden and Provo)
Instructor draw regional map
"Drawing Regional Map" slideshow

Break

"**National and Regional Geography**" presentation

Testable Material:

- Interstate numbering system
- Cities in each UDOT Region
- MP 270, 300, 340
- MP on I-215
- Lakepoint Junction, Point of the Mountain, Silver Creek Junction, Kimball Junction
- North Interchange, South Interchange, Spaghetti Bowl, Parley's Canyon
- Surface street grid: State, Bangerter, Redwood, California, I-215 South, I-215 West
- Special events locations
- Economic/population centers

Draw State Map (guidance = state boundaries, alternate routes)
Instructor draw state map

APPENDIX F

CONSOLE SCRIPT

What Is Difficult About Working at the UDOT TOC

Three things:
1. Hearing/understanding incident location on radio
2. Selecting the correct device (camera) to view
3. Orienting the camera/locating the incident

These three things are the ones that we have to perfect in the TOC at a console

ATMS Software Introduction

VCS Video Control System
Device list (cameras listed by freeway, in MP order)
Output video devices (console, wall, DPS, media, Davis county)
Dragging a feed from device list to an output; from one output to another
Pan, Tilt, Zoom
Block or Lock a camera view; when is it appropriate to do so

TIS Traveler Information System
The name of the sign is also the location of the sign
Message Library v/s Quick Message
Keep is simple – two lines are better than three
Use phasing only if absolutely necessary
Know the location of the signs so you don't have to search for one

IMS Incident Management System
Active incident log (how to retrieve information and notes from an active incident)
Cleared incident log (how to re-open an incident if necessary)
New Incident (step-by-step selection)
Using "Cross Street" or "Address" to identify location
Acknowledging incident
Making changes as incident is managed

ATMS Map
"Home View"
Navigating around map (zoom, drag, etc.)
Introduce all layers (incident, cameras, signs, and MP should always be on)
Note that cameras appear on the correct side of the road (where they really are on the ground)

CAD Computer Automated Dispatch
Open from "Programs;" enter login and password
Select "Status" → "Incident"
Enter "S,U" in the "Term" box for Salt Lake and Utah county incidents
Explain block by block (10-codes should have been introduced in classroom)
Explain how to get CAD online through Commuterlink website if unavailable

Other Programs
VECC Valley Emergency Communications Center CAD
Salt Lake City Police Department CAD
Mapquest map or Google Earth image of SLC

Orienting Your View to a Camera Image

Shadows (good morning and evening, not mid-day)
Topography (big mountains, little mountains, lakes)
Mountain in West at northern end of Oquirrah Mountains
"Ugly mountain" in North at SL-Davis county line
Landmarks (downtown, malls, structures)
Overall traffic flow (during commute periods)
Guide Signs (see what exit or MP is ahead of you with respect to where the camera is located)
Knowing which side of the road the camera is on (use ATMS Map)

*Without making them select an incident location, have them pull up random camera images and talk through the above methods:
I-80 at 1000W: downtown in the distance
SR201 at 800W: mountain in the West
I-15 at 400S SW: mountain in the North
I-15 cameras are all good for shadows (as long as it's early or late)
Parley's Canyon: all cameras marked "ns" (North side) or "ss" (South side) of the freeway
I-215W at 5100S: looking South, can see "Redwood Road" guide signs and you can see the road curving to the East where it becomes I-215 South

Incident Locations

"Connector from US40 West to I-80 West"
Teaching Points:
- US40 is West, not North as most assume
- There are very few landmarks with which to orient your view
- Easiest way to recognize is that SPIU cannot be I-80, so I-80 must be on the bottom
- There will be two ramps, one for US40 West and one for Silver Creek Road. Silver Creek Road will have to go up to the SPUI and through the signal. US40 West will get their own flyover ramp
- If operator has no idea what you're talking about, go back to Regional Map (make them draw it if necessary) and talk them into Silver Creek Junction

"I-15 at 12300 South SB Offramp"
Teaching Points:
- 12300 South camera will be the first they choose; however it is no good because it is on the East side and is not high enough to see the mainline traffic
- When they select the 11900 South camera next, point out how it offers a much better view even though it's about a half mile away
- Point out how you can see the first half of the ramp with the 11900 South camera, and you have to get the 12400 South camera to see the second half of the ramp

"I-80 West Eastbound at 2200 West"
- Operator may look for a grid numbered camera close to 2200 West without realizing that 2200 West is right under the I-215 West interchange
- Once they understand it is under I-215, they have to choose from the NE or SW camera (or both) to see the entire stretch of I-80. Good segway into discussion of I-80/I-215 interchange

"SB Bangerter Highway at 2700 West"
- Operator should be confused initially because they'll expect all Bangerter Highway cross streets to be North/South numbers on the grid; many do not realize that it turns to the East at 14000 South

Locating Incidents in Interchanges

Before you look for anything, envision what the traffic is doing on a map
Consult imagery of interchange
Select a camera that can see the traffic as they enter the interchange; follow them until you can't see them anymore; ID a reference point that you can find from another camera
Select another camera farther in the interchange; pick up connector ramp from where you lost it with the previous camera

South Interchange
Spaghetti Bowl
North Interchange
I-80 and I-215
Parley's Canyon

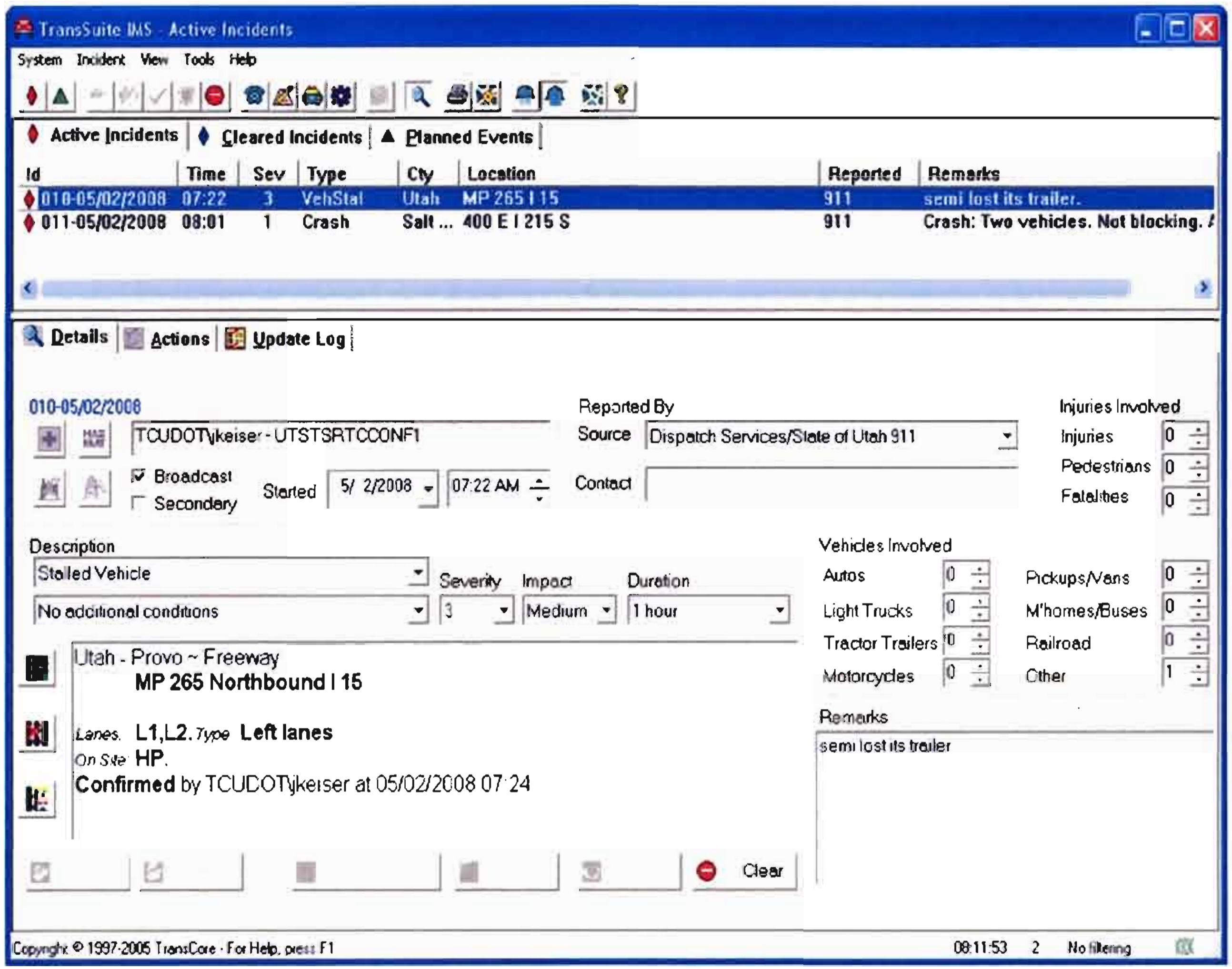
"Connector from SR201 EB to I-15 NB"
- Best camera to see initial portion of the ramp is 201 at 800 West
- Point out that 2100 S 700 W camera is a surface street camera; explain how 2100 South and 201 are different; 201 is often referred to as the "2100 South Freeway," which is confusing

"I-215 East NB to I-80 East Westbound"
- Best camera for initial view is 'I-215 East Parley's Canyon'
- 'Foothill S to I-80' is best for following it beyond Parley's

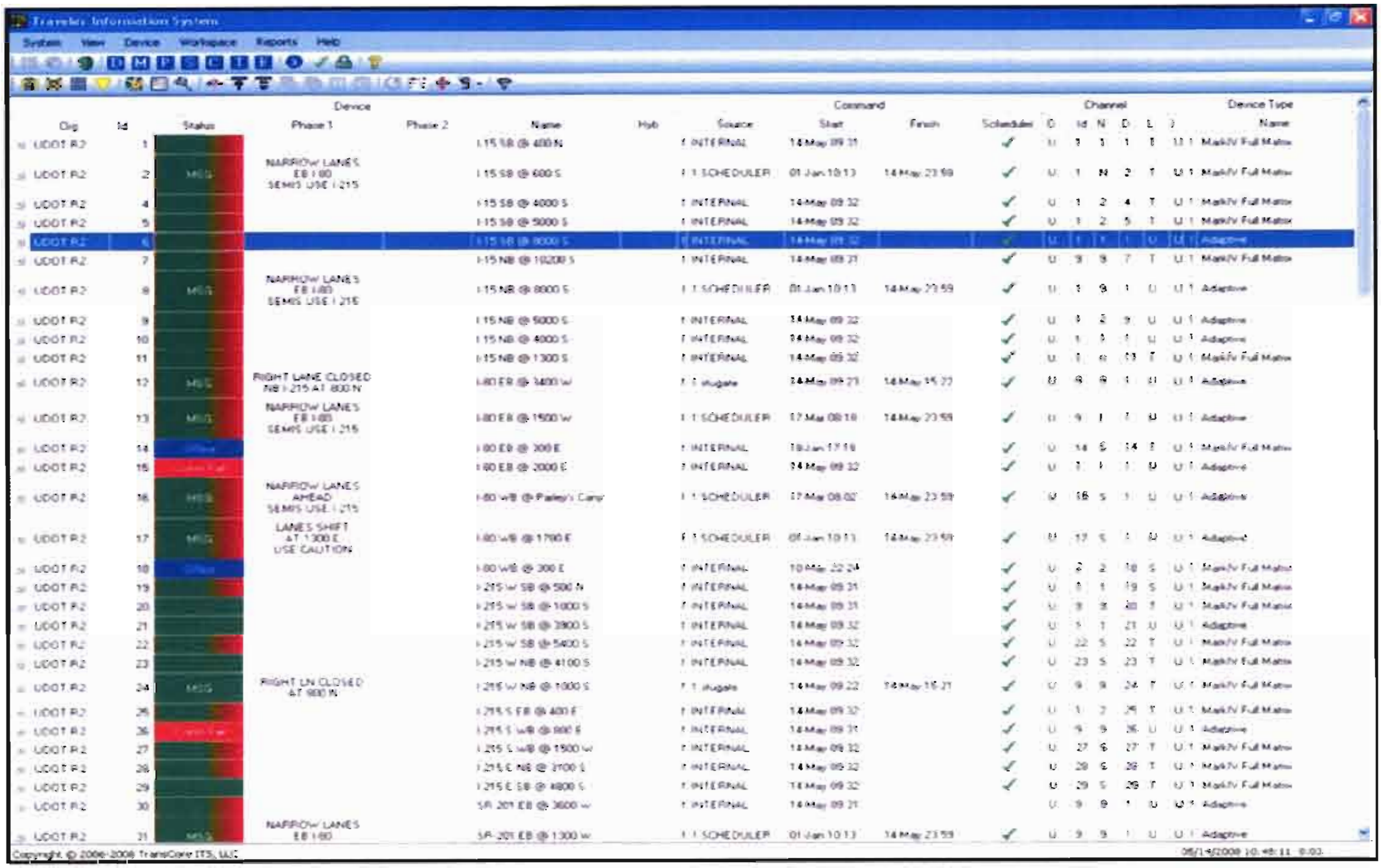
APPENDIX G

SOFTWARE SCREENSHOTS

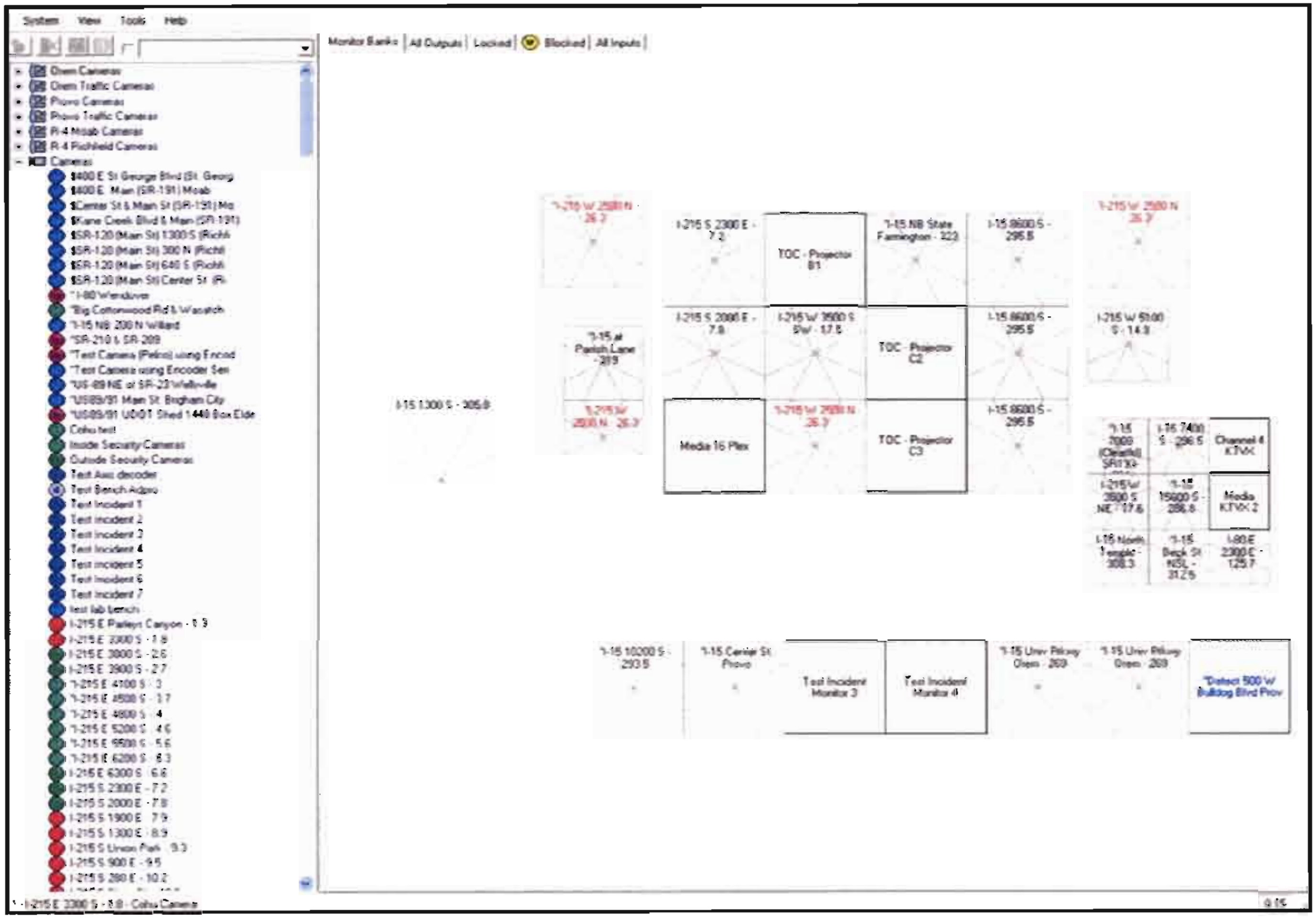
IMS: Incident Management System



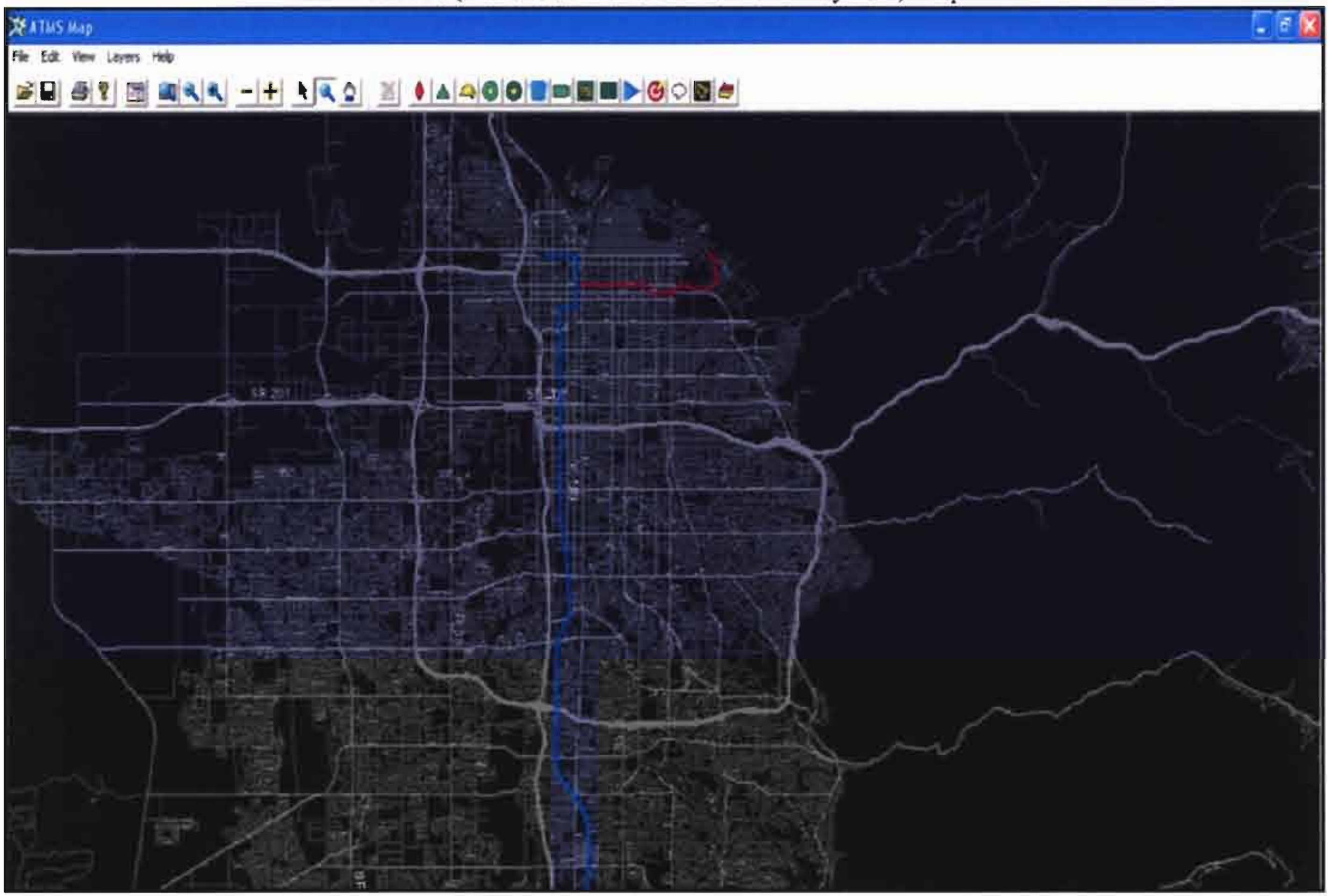
TIS: Traveler Information System



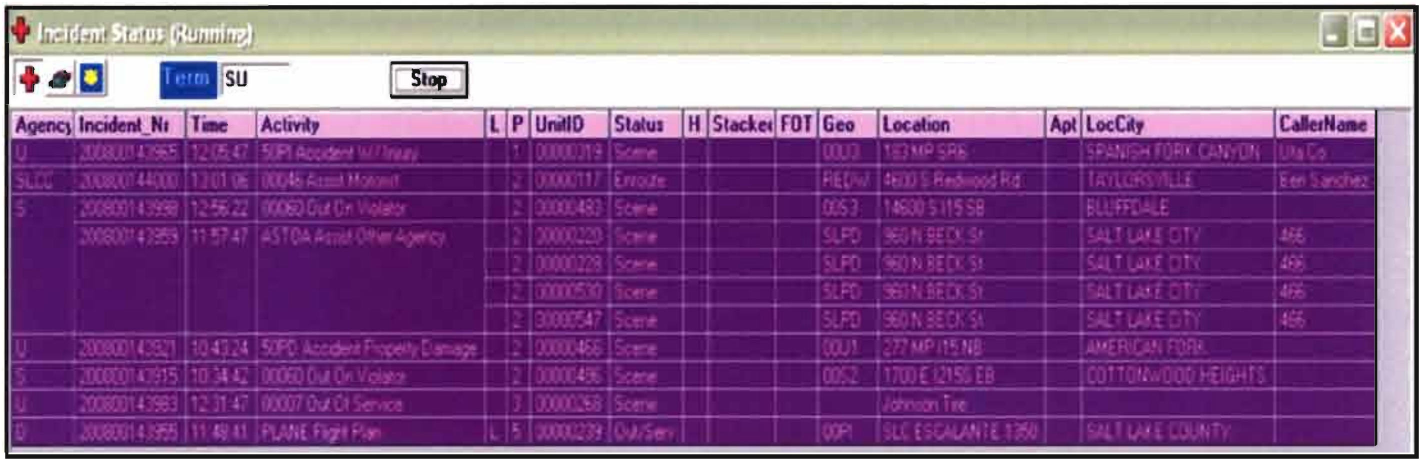
VCS: Video Control System



ATMS (Advanced Traveler Information System) Map



CAD: Computer Automated Dispatch


Incident Status (Running)

Term SU Stop

Agency	Incident_Nr	Time	Activity	L	P	UnitID	Status	H	Stacked	FOT	Geo	Location	Apt	LocCity	CallerName
U	200800143965	12:05:47	50PI Accident W/ Injury		1	00000319	Scene				00U3	193 MP SR6		SPANISH FORK CANYON	Uta Co
SLCC	200800144000	13:01:06	00046 Assist Motorist		2	00000117	Enroute				REDW	4600 S Redwood Rd		TAYLORSVILLE	Een Sanchez
S	200800143998	12:56:22	00060 Out On Violator		2	00000483	Scene				00S3	14600 S I15 SB		BLUFFDALE	
	200800143959	11:57:47	ASTOA Assist Other Agency		2	00000220	Scene				SLPD	960 N BECK St		SALT LAKE CITY	466
					2	00000228	Scene				SLPD	960 N BECK St		SALT LAKE CITY	466
					2	00000530	Scene				SLPD	960 N BECK St		SALT LAKE CITY	466
					2	00000547	Scene				SLPD	960 N BECK St		SALT LAKE CITY	466
U	200800143921	10:43:24	50PD Accident Property Damage		2	00000466	Scene				00U1	277 MP I15 NB		AMERICAN FORK	
S	200800143915	10:34:42	00060 Out On Violator		2	00000496	Scene				00S2	1700 E I215 EB		COTTONWOOD HEIGHTS	
U	200800143983	12:31:47	00007 Out Of Service		3	00000258	Scene					Johnson Tire			
D	200800143955	11:48:41	PLANE Flight Plan	L	5	00000239	Out/Serv				00PI	SLC ESCALANTE 1350		SALT LAKE COUNTY	

APPENDIX H

ROADSIDE IMAGES

Urban Freeway Segment

Single Point Urban Interchange (SPUI)

Connector Ramp

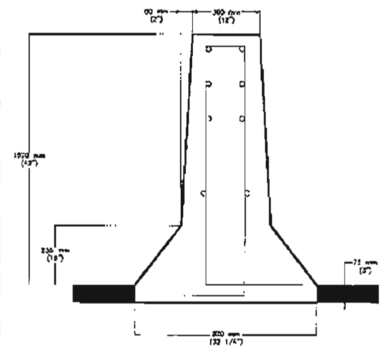
Interstate Highway Map

Barriers

Crash Attenuator

Connecticut Barrier

Jersey Barrier



Interstate Route Designator

Milepost Marker

Sign Types

Regulatory Sign

Warning Sign

Guide Sign

Information Sign

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